Oxygenation, Saturation, and Salinity

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Dissolved Oxygen and Saturation

The dissolved oxygen levels in water are influenced by several factors, including temperature, salinity, and the time of day. Monitoring these parameters is crucial to maintaining healthy conditions for marine shrimp production. Oxygenation and saturation levels need to be carefully controlled to avoid issues such as hypoxia or oxygen excess, which can lead to problems like reduced growth rates or bubble disease.

Oxygen Concentration (mg/L) According to Temperature and Salinity

The following table outlines the oxygen concentration measured at different times, salinity levels, and temperatures. The measured oxygen is compared with tabulated values to determine the saturation percentage and the oxygen status (deficit or excess).

Time	Salinity (‰)	Temperature (°C)	Measured O_2 (mg/L)	Tabulated O_2 (mg/L)	Saturation (%)	Oxygen Status
07:00	15	24	1.2	7.7	15.5	Lacking 84.5%
17:00	15	27	12.9	7.3	176.7	Excess 76.7%
07:00	40	28	1.2	6.2	19.3	Lacking 80.7%
17:00	40	33	12.9	5.7	226.3	Excess 126.3%

These measurements illustrate the variability of oxygen saturation throughout the day, influenced by temperature and salinity. It is essential to maintain appropriate levels of oxygen to ensure the well-being of the shrimp. Early morning measurements often show lower saturation levels, indicating a deficit in oxygen, while afternoon readings can show an excess due to increased photosynthetic activity and higher temperatures.

Suitable Saturation Ranges for Production

The following table summarizes the suitable saturation ranges for shrimp production and the associated conditions:

Saturation (%)	Condition
> 200	Bubble disease
50 - 200	Optimal range
< 50	Hypoxia/Anoxia

- **Above 200%**: When the oxygen saturation exceeds 200%, there is a significant risk of bubble disease, which can be harmful to shrimp health. This condition occurs when excessive oxygen forms bubbles that can lodge in the tissues of the shrimp, causing physical damage and stress.
- **50% to 200%**: This range is considered optimal for shrimp growth and overall health. Maintaining oxygen levels within this range promotes efficient growth rates, good feed conversion, and low disease susceptibility.
- **Below 50%**: When oxygen saturation drops below 50%, the risk of hypoxia (low oxygen) or anoxia (no oxygen) increases, which can lead to mortality. In this condition, shrimp are unable to meet their metabolic oxygen demands, which severely impacts their growth and survival.

Maintaining proper oxygenation is crucial for maximizing shrimp health and productivity. The goal is to keep oxygen saturation in the optimal range to promote the best possible outcomes for growth and overall farm success.

Production Statistics

The following table provides data on shrimp production at different oxygen saturation levels, including yield, feed conversion ratio (FCR), and feed costs:

Saturation (%)	Yield (kg/ha)	Feed Conversion Ratio (FCR)	Feed (kg)	Feed Cost (US$/kg)	Feed Cost (US$)
40	3,631	1.9	6,898	1.2	8,277
65	3,975	1.4	5,565	1.2	6,678

- **Savings per hectare**: By increasing oxygen saturation from 40% to 65%, there is a significant reduction in feed costs and an increase in yield. The savings per hectare amount to $1,600, which highlights the importance of maintaining adequate oxygen levels for cost-effective production.
- **Savings for a 500 ha farm**:
  - $800,000 per cycle
  - $1,600,000 per year
  - **Total revenue with 25% O_2 saturation increase**: With a 25% increase in oxygen saturation, the total revenue can reach $2,632,000 per year, demonstrating the economic benefits of effective oxygenation management.

Maintaining higher oxygen saturation levels not only improves shrimp health and growth but also leads to substantial financial benefits for farmers. Optimizing

oxygen levels is a key strategy for reducing costs and increasing profitability.

Oxygenation vs. Aeration

It is important to distinguish between oxygenation and aeration, as both processes play a role in maintaining adequate oxygen levels in shrimp ponds:

- **Oxygenation**: This involves dissolving pure oxygen directly into the water. It is a more controlled process and is typically used when precise oxygen levels are required, especially during periods of high oxygen demand or stress.
- **Aeration**: Aeration, on the other hand, involves dissolving atmospheric oxygen through water turbulence. This process increases the oxygen content by mixing air into the water. Aeration is often used to maintain baseline oxygen levels and prevent hypoxia.

Choosing between oxygenation and aeration depends on the specific needs of the shrimp farm, the current oxygen levels, and the desired outcomes. Both methods can be used in combination to achieve optimal oxygenation for shrimp health and growth.

Comparative Tests

The following table presents data from comparative tests conducted in Peru and Mexico, highlighting the Standard Oxygen Transfer Rate (SOTR), Standard Aeration Efficiency (SAE), and the associated costs:

Location	SOTR (kg O_2/h)	SAE (kg O_2/kWh)	Cost per kWh (US$)	Cost per kg O_2 (US$)
Peru	2.3	1.55	0.074	0.05
Mexico	2.3	1.55	0.10	0.06

- **Standard Oxygen Transfer Rate (SOTR)**: The SOTR measures the rate at which oxygen is transferred to the water. In these tests, the SOTR was 2.3 kg/h at a salinity of 35 ‰ using a 2 HP aerator.
- **Energy Efficiency (SAE)**: The SAE value of 1.55 kg O_2/kWh indicates the efficiency of the aerator in terms of the amount of oxygen transferred per unit of energy consumed. Lower energy costs lead to more economical aeration, which is crucial for large-scale operations.

The comparative tests demonstrate the importance of selecting energy-efficient aeration equipment to minimize costs. The differences in electricity costs between Peru and Mexico also highlight the impact of local energy prices on the overall cost-effectiveness of oxygenation strategies.

Oxygen Transfer Requirements

The following table provides information on the oxygen transfer requirements for

different Standard Oxygen Transfer Rates (SOTR) and the corresponding oxygen demand in mg/L/h:

SOTR (kg/h)	Oxygen Demand (mg/L/h)
0.5	6.44 - 58
0.75	4.29 - 38.61
1	3.22 - 28.96
1.25	2.57 - 23.17
1.5	2.15 - 19.31
1.75	1.84 - 16.55
2	1.61 - 14.48
2.25	1.43 - 12.87
2.5	1.29 - 11.58
2.75	1.17 - 10.53
3	1.07 - 9.65

These requirements help in determining the number of aerators needed for a given pond size based on the oxygen demand. Ensuring the correct SOTR is critical for maintaining suitable oxygen levels and preventing hypoxia or other oxygen-related issues.

Proper planning and understanding of the oxygen transfer requirements allow farmers to optimize their aeration systems and achieve better results in shrimp production. By using the appropriate equipment and maintaining efficient aeration, farmers can enhance shrimp growth, reduce mortality, and improve overall farm profitability.

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